

Transformers

More than meets the eye

Two sets of coils of wire with a common core.

Input current through the primary.

Get an output current in the secondary

if: N_p N_s \leftarrow number of loops



Primary

Secondary

$$B \propto I \times N_p$$

$$E_{\text{ind}} = -N_s \frac{\Delta \Phi}{\Delta t}$$

\triangle change

So if B is constant (DC)

- No induced current

Big Idea: Transformers require AC or

a change in current in the primary to give a current in the secondary.

$$N_p/N_s = V_p/V_s$$

N is the number of loops of wire, p is primary, s is secondary

V is the voltage or emf in the primary or secondary

By conservation of energy, power out must be at most equal to the power in.

$P_{out} = P_{in}$ ideal transformer

$$V_s I_s = V_p I_p$$

$$V_p/V_s = I_s/I_p = N_p/N_s$$

$$\varepsilon_p/\varepsilon_s = I_s/I_p = N_p/N_s$$
 IB data book

eg.

You want to send 5.0 MW of energy through cables with 2.0Ω of resistance.

How much power is lost if you send the energy at

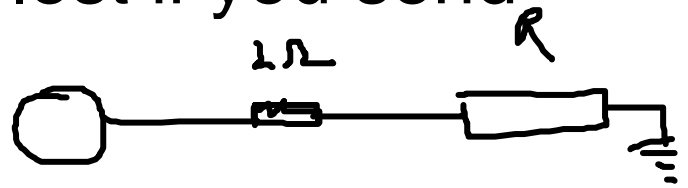
a) 20 000V

b) $P=VI$

$$I = 5.0\text{MW}/20000\text{V} = 2.5 \times 10^2\text{A}$$

$$P_{\text{lost}} = I^2 R = 250^2 \times 2 = 125,000 \text{ W}$$

$$125000/5000000 = 0.025 \text{ } 2.5\% \text{ loss}$$



b) 120V -

$$I = 5.0\text{MW}/120\text{V} = 50000000/120 = 416666.6667 \text{ A}$$

$$P_{\text{lost}} = I^2 R = 416666.6667^2 \times 2 = 3.4722\text{E}11 \text{ W}$$

way more power out than in

c) use two transformers that are 98% efficient to take the energy from the input of 120V up to 20 000V for

transmission and then down to
120V at your house.

$$V_{sls} = 0.98V_{plp}$$

P_{lost} is first transformer

$$0.02 \times 5000000 = 100\,000\text{W}$$

$$I_s = (0.98 \times 5000000) / 20000 = 245\text{A}$$

$$P_{lost \text{ in cables}} = 245^2 \times 2 = 120,050\text{W}$$

P_{lost} in second transformer

$$0.02 \times ((245 \times 20000) - 120050) = 95599.0$$

$$\text{total loss} = 100000 + 120,050 + 95599.0 = 315649\text{ W}$$

$$315649 / 5000000 = 0.0631 = 6\% \text{ loss}$$

Which is most efficient? Why don't we do it that way?

step up transformer - goes from low voltage to high voltage (current goes down proportionally)

step down transformers - steps down the voltage - at your house - so it is not so dangerous.

a) sketch the input and output V and current graphs of the first transformer.